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Mazdoor Kisan Shakti Sangathan

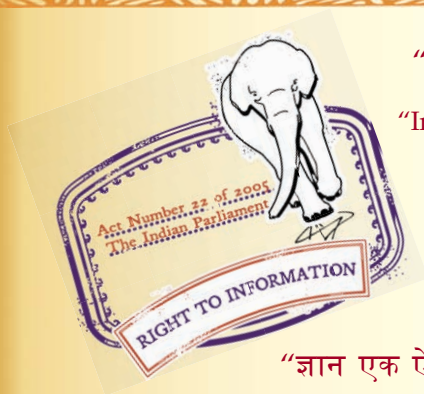
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IS 3824-2 (1983): Method of Evaluating Dynamic Load Ratings of Rolling Bearings, Part 2: Radial Roller Bearings [PGD 13: Bearing]



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“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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*Indian Standard***METHODS OF EVALUATING DYNAMIC
LOAD RATINGS OF ROLLING BEARINGS****PART 2 RADIAL ROLLER BEARINGS***(First Revision)*

1. Scope — Covers the methods for calculating the basic dynamic load ratings and rating life of radial roller bearings.

1.1 The standard also specifies methods of calculation of adjusted ratings life to take into account various reliabilities, materials and operating conditions.

1.2 This standard is not applicable to design where the rolling elements operate directly on a shaft or housing surface, unless that surface is equivalent in all respects to the bearing rings (or washers) raceway it replace.

2. Definitions

2.1 Life — For an individual rolling bearing, the number of revolutions which one of the bearing rings (or washers) makes in relation to the other rings (or washers) under the prevailing working conditions before the first evidence of fatigue develops in the material of one of the rings (or washers) or rolling elements.

2.2 Reliability (In the context of bearing life) — For a group of apparently identical rolling bearings, operating under the same conditions, the percentage of the group that is expected to attain or exceed a specified life.

2.2.1 The reliability of an individual rolling bearing is the probability that the bearing will attain or exceed a specified life.

2.3 Basic Rating Life — For an individual rolling bearing, or a group of apparently identical rolling bearings operating under the same conditions, the life associated with 90 percent reliability.

2.4 Basic Dynamic Radial Load Rating — That constant stationary radial load which a rolling bearing can theoretically endure for a basic rating life of one million revolutions. In the case of a single row angular contact bearing, the radial load rating refers to the radial component of that load which causes a purely radial displacement of the bearing rings in relation to each other.

2.5 Basic Dynamic Axial Load Rating — That constant centric axial load which a rolling bearing can theoretically endure for a basic rating life of one million revolutions.

2.6 Dynamic Equivalent Radial Load — That constant stationary radial load under the influence of which a rolling bearing would have the same life as it will attain under the actual load conditions.

2.7 Dynamic Equivalent Axial Load — That constant centric axial load under the influence of which a rolling bearing would have the same life as it will attain under the actual load conditions.

2.8 Roller Diameter Applicable in the Calculation of Load Ratings — The diameter at the middle of the roller.

Note 1 — For a tapered roller this is equal to the mean value of the diameters at the theoretical sharp corners at the large end and the small end of the roller.

Note 2 — For an asymmetrical convex roller this is an approximation for the diameter at the point of contact between the roller and the ribless raceway at zero load.

2.9 Roller Length Applicable in the Calculation of Load Ratings — The theoretical maximum length of contact between a roller and that raceway where the contact is shortest.

Note — This is normally taken to be either the distance between the theoretical sharp corners of the roller minus the roller chamfers or the raceway width excluding the grinding undercuts, whichever is the smaller.

2.10 Nominal Contact Angle — The angle between a plane perpendicular to the bearing axis and the nominal line of action of the resultant of the forces transmitted by a bearing ring to a rolling element.

3. Symbols — For the purpose of this standard, the following symbols shall apply:

- C_r = Basic dynamic radial load rating, newtons
- C_a = Basic dynamic axial load rating, newtons
- D_{we} = Roller diameter applicable in the calculation of load ratings, millimetres
- D_{pw} = Pitch diameter of roller set, millimetres
- F_r = Bearing radial load = radial component of actual bearing load, newtons
- F_a = Bearing axial load = axial component of actual bearing load, newtons
- L_{10} = Basic rating life, million revolutions
- L_n = Adjusted rating life for a reliability of $(100 - n)$ percent, million revolutions
where n = Adjusted rating life
- L_{10s} = Adjusted rating life for non-conventional material and operating conditions, million revolutions
- L_{na} = Adjusted rating life for non-conventional material and operating conditions and for a reliability of $(100 - n)$ percent, million revolutions
- L_{we} = Roller length applicable in the calculation of load ratings, millimetres
- P_r = Dynamic equivalent radial load, newtons
- P_a = Dynamic equivalent axial load, newtons
- X = Radial load factor
- Y = Axial load factor
- Z = Number of balls or rollers in a single row bearing, number per row of a multi-row bearing with equal number of rollers per row
- a_1 = Life adjustment factor for a reliability other than 90 percent
- a_2 = Life adjustment factor for non-conventional material
- a_3 = Life adjustment factor for non-conventional operating conditions
- e = Limit value of F_a/F_r for the applicability of different values of factors X and Y
- f_c = A factor which depends on the geometry of the bearing components, the accuracy to which the various components are made and material
- i = Number of rows of rollers in a bearing
- α = Nominal contact angle of a bearing, degrees

4. Basic Dynamic Radial Load Rating — The basic dynamic radial load rating for radial roller bearings shall be given by:

$$C_r = f_c (i L_{we} \cos \alpha)^{7/19} Z^{3/4} D_{we}^{29/27}$$

Values of factor f_c shall be as given in Table 1. They are maximum values, only applicable to roller bearings in which, under a bearing load, the material stress is substantially uniform along the most heavily loaded roller/raceway contact.

Smaller values of factor f_c than those given in Table 1 shall be used if, under load, an accentuated stress concentration is present in some part of the roller/raceway contact. Such stress concentrations must be expected, for example, at the centre of nominal point contacts, at the extremities of line contacts, in bearings where the rollers are not accurately guided and in bearings with rollers longer than 2.5 times the roller diameter.

TABLE 1 VALUES OF FACTOR f_c FOR RADIAL ROLLER BEARINGS

(Clause 4)

$\frac{D_{we} \cos \alpha}{D_{pw}}$	f_c
0.01	52.1
0.02	60.8
0.03	66.5
0.04	70.7
0.05	74.1
0.06	76.9
0.07	79.2
0.08	81.2
0.09	82.8
0.10	84.2
0.12	86.4
0.14	87.7
0.16	88.5
0.18	88.8
0.20	88.7
0.22	88.2
0.24	87.5
0.26	86.4
0.28	85.2
0.30	83.8

Note — Values of f_c for intermediate value of $\frac{D_{we} \cos \alpha}{D_{pw}}$ are obtained by linear interpolation.

4.1 When calculating the basic radial load rating for two similar single row roller bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in ' back-to-back ' or ' face-to-face ' arrangement, the pair is considered as one double row bearing.

If for some technical reason the bearing arrangement is regarded as two bearings which are replaceable independently of each other, the above paragraph does not apply.

4.2 The basic radial load rating for two or more similar single row roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in ' tandem ' arrangement, properly manufactured and mounted for equal load distribution, is the number of bearings to the 7/9 power times the rating of one single row bearing.

If for some technical reason the bearing arrangement is regarded as a number of single row bearings which are replaceable independently of each other, the above paragraph does not apply.

5. Dynamic Equivalent Radial Load — The equivalent radial load for radial roller bearings with $\alpha \neq 0^\circ$, under constant radial and axial loads, shall be given as:

$$P_r = X F_r + Y F_a$$

Values of factors X and Y shall be as given in Table 2.

The equivalent radial load for radial roller bearings with $\alpha = 0^\circ$, and subjected to radial load only, is

$$P_r = F_r$$

Note — The ability of radial roller bearings with $\alpha = 0^\circ$, to support axial loads varies considerably with bearing design and execution. The bearing user should, therefore, consult the bearing manufacturer for recommendations regarding the evaluation of equivalent load and life in cases where bearings with $\alpha = 0^\circ$ are subjected to axial load.

TABLE 2 VALUES OF FACTORS X AND Y FOR RADIAL ROLLER BEARINGS

(Clauses 5, 5.1, 5.2 and 6.1)

Bearing Type	$\frac{F_a}{F_r} < e$		$\frac{F_a}{F_r} > e$		e
	X	Y	X	Y	
Single row, $\alpha \neq 0$	1	0	0.4	$0.4 \cot \alpha$	$1.5 \tan \alpha$
Double row, $\alpha \neq 0$	1	$0.45 \cot \alpha$	0.67	$0.67 \cot \alpha$	$1.5 \tan \alpha$

5.1 When calculating the equivalent radial load for two similar single row angular contact roller bearings mounted side by side on the same shaft such that they operate as a unit (paired mounting) in 'back-to-back' or 'face-to-face' arrangement, and which according to 4.1, is considered as one double row bearing, the X and Y factors for double row bearings in Table 2 are used.

5.2 When calculating the equivalent radial load for two or more similar single row angular contact roller bearings mounted side by side on the same shaft such that they operate as a unit (paired or stack mounting) in 'tandem' arrangement, the X and Y factors for single row bearings in Table 2 are used.

6. Basic Rating Life -- The basic rating life for radial roller bearings shall be given as:

$$L_{10} = \left(\frac{C_r}{P_r} \right)^{10/3}$$

The values of C_r and P_r are calculated in accordance with 5.1 and 5.2.

6.1 This life formula is also used for the evaluation of the life of two or more single row bearings operating as a unit, as referred to in 4.1 and 4.2. In this case the load rating C_r is calculated for the complete bearing arrangement and the equivalent load P_r is calculated for the total loads acting on the arrangement, using the values of X and Y indicated in 5.1 and 5.2.

6.2 The life formula gives satisfactory results for a broad range of bearing loads. However, extra heavy load may cause accentuated stress concentrations in some part of the roller/raceway contacts. The user shall, therefore, consult the bearing manufacturer to establish the applicability of the life formula in case where P_r exceeds $0.5 C_r$.

7. Adjusted Rating Life

7.1 General

7.1.1 Reliability level — The normal criterion of bearing performance is the basic rating life calculated according to this standard and this life is associated with 90 percent reliability. However, for certain applications it may be desirable to calculate the life for other reliability levels.

The adjusted rating life for a reliability of $(100 - n)$ percent shall be

$$L_n = a_1 L_{10}$$

Values of factor a_1 are given in 7.2.

7.1.2 Material and operating conditions — It is recognised that the properties of the material and the operating conditions have an influence on bearing life. The basic rating life calculated according to this standard is associated with conventional material (good quality, hardened steel) and conventional operating conditions (a bearing properly mounted, adequately lubricated, protected from foreign matter, conventionally loaded and not exposed to extreme temperature).

In certain cases the bearing material characteristics and/or operating conditions deviate from the conventional in such a way that it is justified to take their influence into special consideration.

The adjusted rating life for non-conventional material and operating conditions shall be given as:

$$L_{10a} = a_2 a_3 L_{10}$$

The adjusted rating life for non-conventional material and operating conditions and for a reliability of $(100 - n)$ percent shall be given as:

$$L_{na} = a_1 a_2 a_3 L_{10}$$

For values of factors a_2 and a_3 see 7.3 and 7.4.

7.1.3 Limitations — In addition to the required fatigue life, other factors such as maximum permissible bearing deflection and minimum shaft and housing strength, shall be given due consideration when selecting the size of bearings for a given application. Particular discretion shall be exercised when utilizing adjusted rating life values which are greater than L_{10} .

7.2 Life Adjustment Factor for Reliability — The adjusted rating life for a reliability of $(100 - n)$ percent shall be calculated in accordance with 7.1.1. Values of the pertinent adjustment factor a_1 shall be as given in Table 3.

TABLE 3 LIFE ADJUSTMENT FACTOR FOR RELIABILITY, a_1

Reliability Percent	L_n	a_1
90	L_{10}	1
95	L_5	0.62
96	L_4	0.53
97	L_3	0.44
98	L_2	0.33
99	L_1	0.21

7.3 Life Adjustment Factor for Material — Currently the selection of a_2 values cannot be based on quantifiable material characteristics but only on test results and other experience made with bearings. Values of a_2 shall, therefore, be obtained from the bearing manufacturer.

The use of a certain steel analysis and/or process as such is not sufficient justification for the use of an a_2 value other than 1. Values of a_2 greater than 1 may, however, be applicable to bearings made of steel of particularly low impurity content or of special analysis.

Bearing manufacturing processes affecting the properties of the material in a bearing are also to be considered in the selection of an a_2 value. If, for example, a reduced life is expected because of a hardness reduction caused by special heat treatment, this should consequently be considered by the manufacturer's selection of a correspondingly reduced a_2 value.

It may not be assumed that the use of an improved material will overcome a deficiency in lubrication. Values of a_2 greater than 1 should, therefore, normally not be applied where factor a_3 is less than 1 because of such deficiency.

7.4 Life Adjustment Factor for Operating Conditions — Of the operating conditions directly influencing bearing life, the magnitude and direction of the load are considered in the calculation of the equivalent load (5 of Part 1) and deviations from normal load distribution have been explained in the Explanatory Note.

Operating conditions which remain to be taken into account here are the adequacy of the lubrication (at the operating speed and temperature) and conditions causing changes in material properties (for example high temperature causing reduced hardness). The influence on bearing life of such conditions may be considered by the application of a life adjustment factor a_3 .

The calculation of basic dynamic load rating and basic rating life in this standard assumes that bearing life is limited principally by sub-surface fatigue, that is, that the rolling elements and the rings (washers) raceways are sufficiently separated by a lubricant to make the probability of failures caused by surface distress negligible. Where this requirement is fulfilled $a_3 = 1$, provided a lower value does not apply, for example because of a change in material properties caused by the operating conditions.

Reduction of a_3 values should be considered, for example, where the viscosity of the lubricant is less than $20 \text{ mm}^2/\text{s}$ ($1 \text{ mm}^2/\text{s} = 1 \text{ cSt}$) for roller bearings at the operating temperature where the rotational speed is exceptionally low (revolutions per minute multiplied by D_{pw} less than 10 000). Values of a_3 greater than 1 may be considered only where the lubrication conditions are particularly favourable.

It may not be assumed that a deficiency in lubrication can be overcome by using an improved material. Where factor a_3 is less than 1, due to inadequate lubrication, values of a_2 greater than 1 should, therefore, normally not be used.

EXPLANATORY NOTE

This standard was earlier published in 1966. This standard is being revised to align it with ISO 281/1-1977, 'Rolling bearing — Dynamic load ratings and rating life — Part 1 Calculation methods'. In this revision, adjusted rating life of bearings has been included.

This standard consists of the following parts:

IS : 3824 (Part 1)-1983 'Methods of evaluating dynamic load ratings of rolling bearings: Part 1 Radial ball bearings (*first revision*)'

IS : 3824 (Part 2)-1983 'Methods of evaluating dynamic load ratings of rolling bearings: Part 2 Radial roller bearings (*first revision*)'

IS : 3824 (Part 3)-1983 'Methods of evaluating dynamic load ratings of roller bearings: Part 3 Thrust ball bearings (*first revision*)'

IS : 3824 (Part 4)-1983 'Methods of evaluating dynamic load ratings of roller bearings: Part 4 Thrust roller bearings (*first revision*)'

Ball and roller bearings, collectively known as rolling bearings are being used in all modern machines. This specification is included to help manufacturers in the proper design of these bearings.

It is often impractical to establish the suitability of a bearing related for a specific application by testing a sufficient number of bearings in that application. Other methods are, therefore, required to establish this suitability.

A reliable life calculation is considered to be a suitable and advantageous substitute for testing.

Calculation according to this standard do not yield satisfactory results for bearings subjected to such application condition and/or of such internal design which results in considerable truncation of the area of contact between the rolling elements and the ring raceways. Unmodified calculation results are thus not applicable, for example, to groove ball bearings with filling slots which project substantially into a ball/raceway contact area when the bearing is subjected to load in application.

Calculations according to this standard do not yield satisfactory results for bearings subjected to such application conditions which cause deviations from a normal load distribution in the bearing, for example, misalignment, having shaft deflection, rolling element centrifugal forces or other high speed effects, and preload or extra large clearance in radial bearings. Where there is reason to assume that such conditions prevail, the user should consult the bearing manufacturer for recommendations and evaluation of equivalent load and life.